Forest Pest Management
Pacific Southwest Region

Report Number R97-02

3420 Evaluation
October, 1997

Re-Measurement of Disease Survey Plots for White Pine Blister Rust Incidence

John Kliejunas
Plant Pathologist

Background

In 1949-1951, pathologist Reed Miller of the Pest Control Branch (now Forest Pest Management) of Timber Management in the California Region established 10, one acre plots in northern and central California. The objective was to follow incidence of white pine blister rust (*Cronartium ribicola*) in areas of recent blister rust infestation. If rust was present at the time of plot establishment, infected trees were removed. Each one acre plot consisted of 10, one chain (66 ft) square (1/10 acre), blocks in various arrangements. The plots were established in relatively young stands and were usually placed parallel with and in close proximity to a drainage. Records available for each plot included a narrative, giving a general location and description of the plot and associated vegetation; a map of the plot, tying it into some ground feature (usually a Section corner); a summary of the infection data recorded for sugar pine and *Ribes*; and data sheets. In each plot, sugar pines smaller than dbh (4 1/2 feet) were tagged with an approximately 1/4" X 1" metal tag, attached to a branch of the tree with wire. Data recorded for sugar pine during plot establishment included square chain number (1 through 10); tree crown class (dominant, co-dominant, intermediate, suppressed); tree height; tag number (if a sugar pine had a diameter recorded, it was not tagged). Data recorded for *Ribes* included bush number, species, feet of live stem, height of bush, and infection present or not. Some of the plots were re-measured 5 to 8 years after establishment. See Table 1 for a summary of plot locations, dates established, and dates re-visited.

USDA FOREST SERVICE, PACIFIC SOUTHWEST REGION
Forest Pest Management, State and Private Forestry
630 Sansome Street, San Francisco, California 94111

Healthy Forests Make
A World of Difference

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Table 1. Reed Miller Disease Survey Plots.

Original Plot Number	Location	Year Established	Year(s) Re-visited
1	Spaulding Creek (Klamath NF)	1950	1956, 1996
2	Mayflower Ranch[1] (Klamath NF)	1950	1952 (Ribes only), 1955, 1996
3	Bumblebee Creek (Klamath NF)	1949	1953, 1996
4	Buckhorn Lodge[1] (Lassen NF)	1949	destroyed in 1992 Fountain fire
5	Goat Creek[1] (Lassen NF)	1949	destroyed in 1992 Fountain fire
6	Howard Creek[1] (Lassen NF)	1950	1952 , 1953, and 1957 (Ribes only), 1996
7	Spring Garden Ridge[2] (Plumas NF)	1950	1955, 1995
8	Middle Meadows 1 (Eldorado NF)	1949	now a ponderosa pine plantation
9	Middle Meadows 2 (Eldorado NF)	1950	1996
10	Big Canyon Creek (Eldorado NF)	1951	no map to relocate plot

[1] Plot was established on private land within stated National Forest boundaries.
[2] Plot now on private land.

Re-Monumenting of Plots

In 1994 and 1995, Forest Pest Management contracted to have the plots re-located and re-monumented. The objective was to determine which of the 10 plots could be re-located, and if they could be re-located, were they in suitable condition for measurement of blister rust incidence. Nine of the original 10 plots were re-located, and six were re-monumented (Table 1). Original tree tags were found on three of the six re-monumented plots (Spaulding Creek, Spring Garden Ridge, Middle Meadows 2).

1995-1996 Re-Measurement of the Plots

Methods

In 1995 and 1996, Forest Pest Management recorded blister rust incidence on sugar pine and *Ribes* at the six re-monumented plots. The objective was to determine the change in incidence of blister rust since original plot establishment and subsequent re-measurements, if made. When original tags were found, boundaries were established so that the appropriate tree number(s) were in the original 1 chain square block. In the one

instance where an original corner stake was found (Spring Garden Ridge), it was used to re-establish boundaries. A 4 foot metal post and/or a 4 foot section of schedule 80 PVC pipe were placed at the starting point for re-measurements at each plot. Although original tags could not be located on 3 of the 6 plots, the narrative and maps enabled us to approximate the original location within certainly the same slope and drainage as the original plot.

Data recorded for sugar pine included size class (0 - 4.9" dbh, 5 - 10.9" dbh, 11 - 20.9" dbh, and 21" or larger dbh), tree height, and presence of blister rust (number of branch and bole cankers). The number of *Ribes* bushes and presence of rust (yes or no) on each was also recorded.

Results and Discussion

Individual Plots

Information on each of the six Disease Survey plots is presented in the Appendix. For each plot, a graph depicting incidence of rust on sugar pine and/or *Ribes* at each year of measurement is followed by information on stand characterisitcs at time of plot establishment, and information on rust incidence on the hosts for each year of measurement.

Rust Incidence

A total of 469 sugar pines were recorded on the 6 plots. Data on number and percent of sugar pine infected and lethally infected by plot location are presented in Table 2. Percent infection had increased from 0 in 1949-1951 to 12.2% in 1995-1996. Forty of the 469 (8.5%) had lethal bole cankers. Total percent infection ranged from 4.5% at Mayflower Ranch to 18.4% at Bumblebee Creek (Figure 1). Percent of sugar pine with lethal bole cankers ranged from 4.3% at Middle Meadows 2 to 14.5% at Howard Creek.

Table 2. Percent of sugar pine infected by white pine blister rust at six, one acre, plots, 1995-1996.

Original Plot Number	Location	Total Number Sugar Pine	With Rust (total)	Percent Infected (total)	With Rust (lethal)[1]	Percent Infected (lethal)
1	Spaulding Creek	234	25	10.7	18	7.7
2	Mayflower Ranch	22	1	4.5	1	4.5
3	Bumblebee Creek	49	9	18.4	5	10.2
6	Howard Creek	55	8	14.5	8	14.5
7	Spring Garden Ridge	63	8	12.7	6	9.5
9	Middle Meadows 2	46	6	13.0	2	4.3
TOTAL		469	57	12.2	40	8.5

[1] Lethal = bole canker. No attempt was made to determine if branch cankers were lethal (closest margin less than 24 inches from bole) or non-lethal (24 inches or greater from bole).

There was no obvious correlation between rust incidence and plot location within the State. The plots in the Klamath mountains where rust has been present the longest (Spaulding Creek, Mayflower Ranch, Bumblebee Creek) had, on the average, about the same amount of rust (11.2%) as the Middle Meadow 2 plot (13.0%) on the Eldorado, where rust was not yet present in 1950. Some of the higher levels of rust were found on the Howard Creek plot on the Lassen, where rust was not observed until 1957. See individual Disease Survey plot data in Appendix for rust incidence on sugar pine at each year of measurement.

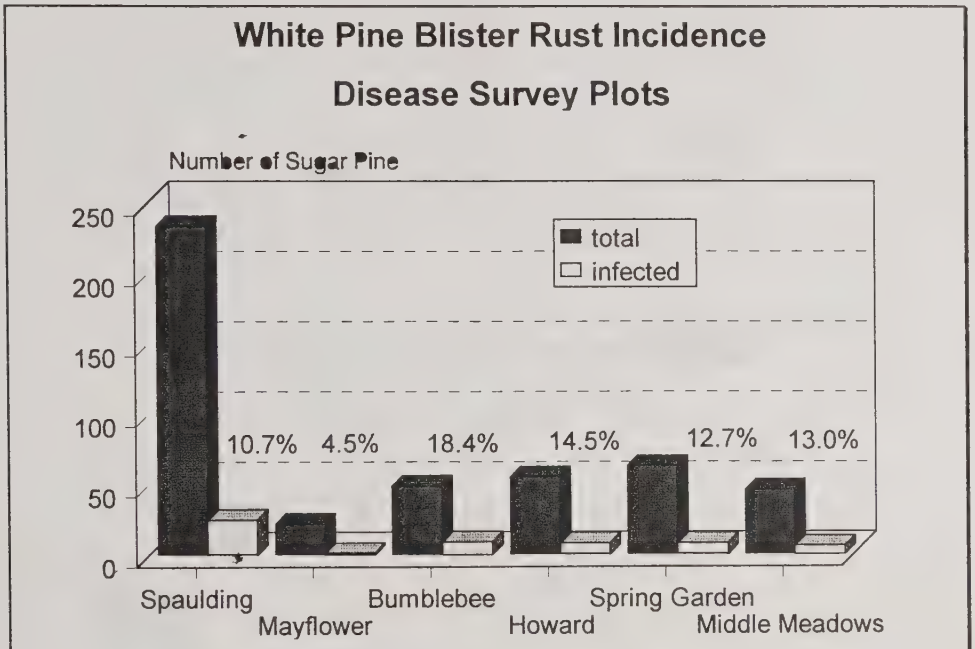


Figure 1. Incidence of blister rust on sugar pine at six Disease Survey Plots, 1995-1996. The percent above each set of bars is the total percent sugar pine infected with rust at each of the six plots.

Other agents of sugar pine mortality were present on the plots, in particular the mountain pine beetle (*Dendroctonus ponderosae*). On the Spaulding Creek plot for example, 18 sugar pine were lethally infected with rust; an additional 38 sugar pine were dead from recent mountain pine beetle attacks.

Rust Incidence by Tree Diameter Class

Incidence of blister rust by tree diameter class on the six plots is presented in Table 3 and Figures 2 (total incidence on six plots) and 3 (incidence on each individual plot). Percent infection by tree diameter class varied with plot location. Overall, infection was greatest on seedlings and saplings, and decreased as tree diameter class increased.

Table 3. Number and percent of sugar pine infected by white pine blister rust, by diameter class, at six, one acre, Disease Survey plots, 1995-1996.

Original Plot Number	Seedling/Sapling (0 - 4.9" dbh)			Pole (5 -10.9" dbh)			Small Sawtimber (11 - 20.9" dbh)			Large Sawtimber (21" & larger dbh)		
	all	rust	%	all	rust	%	all	rust	%	all	rust	%
1	134	16	11.9	81	5	6.2	19	4	21.1	0	0	0
2	16	1	6.3	5	0	0	1	0	0	0	0	0
3	33	6	18.5	14	3	21.5	2	0	0	0	0	0
6	31	5	16.1	7	1	14.3	12	2	16.7	5	0	0
7	30	4	13.3	22	4	18.2	9	0	0	2	0	0
TOTAL	272	35	12.9	134	14	10.4	47	6	12.9	16	2	12.5

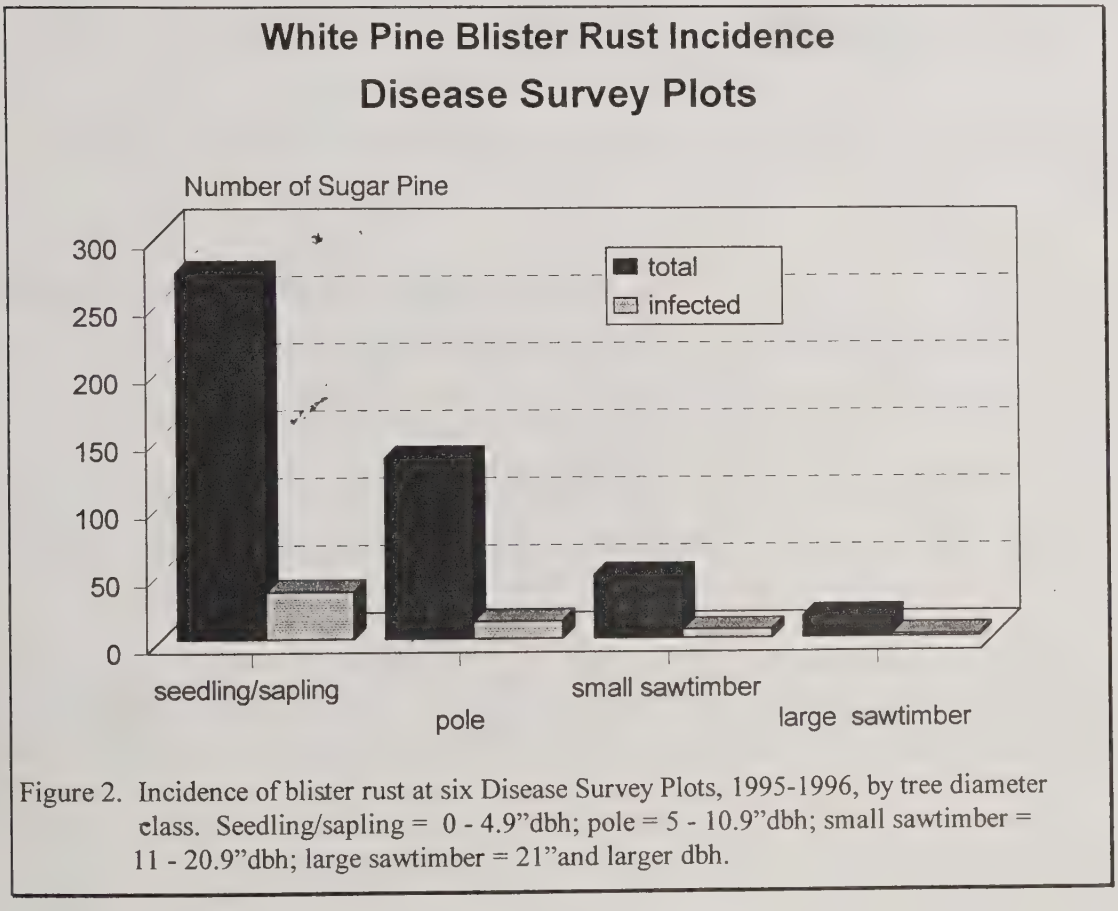
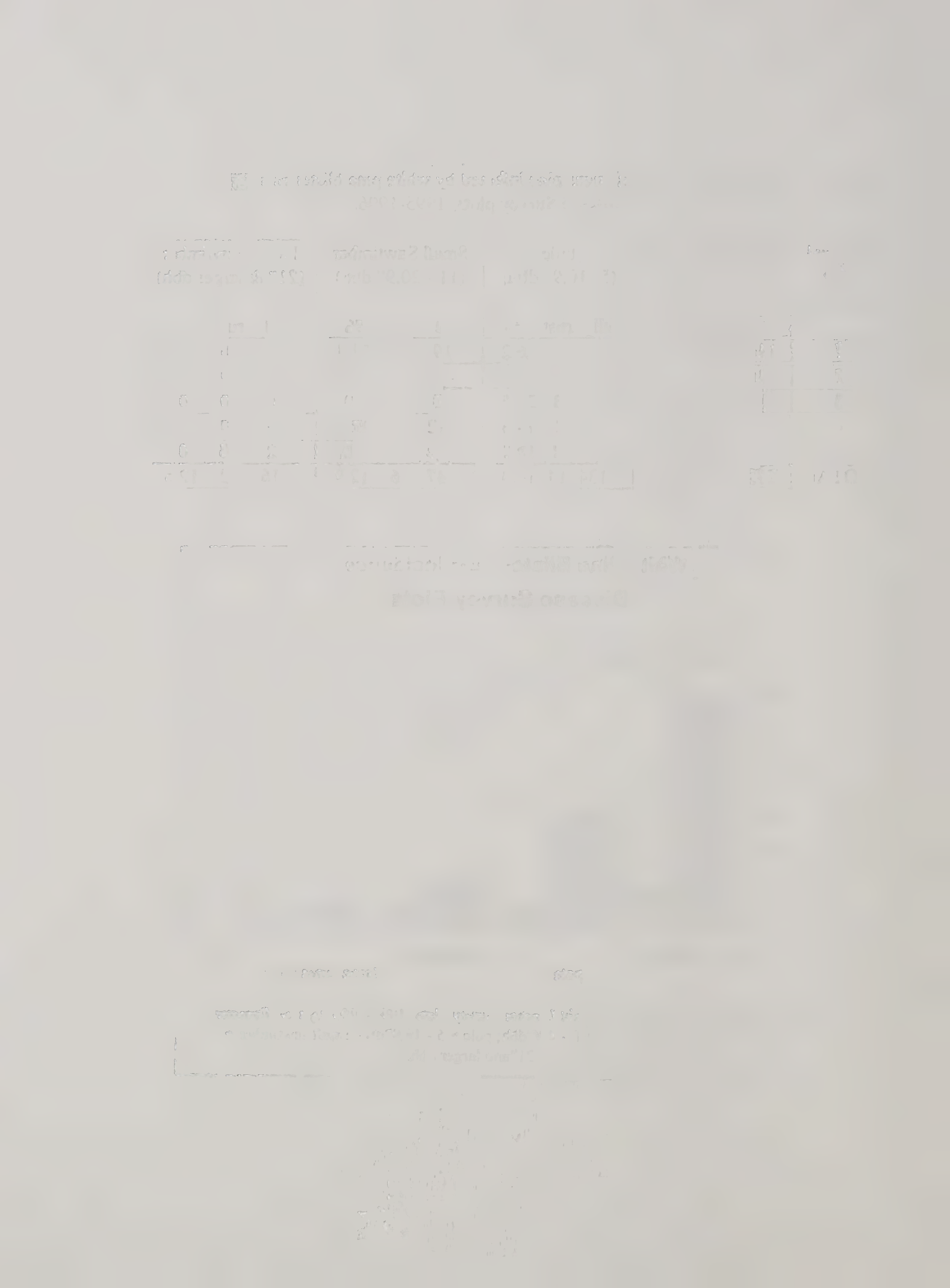


Figure 2. Incidence of blister rust at six Disease Survey Plots, 1995-1996, by tree diameter class. Seedling/sapling = 0 - 4.9"dbh; pole = 5 - 10.9"dbh; small sawtimber = 11 - 20.9"dbh; large sawtimber = 21"and larger dbh.



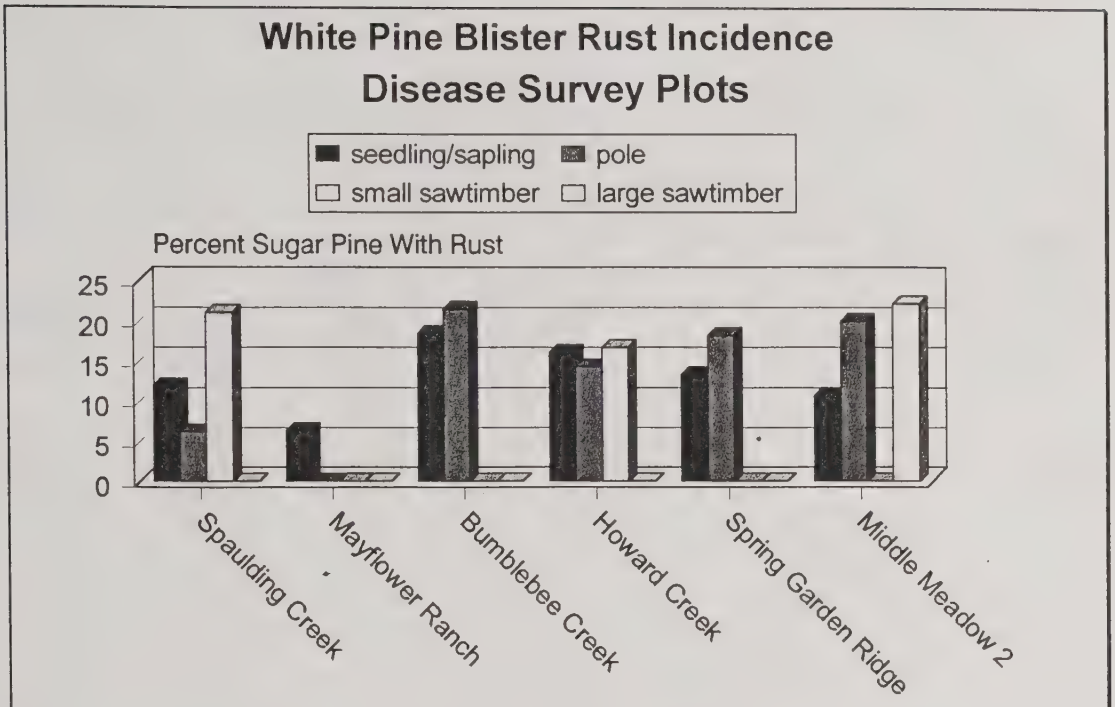


Figure 3. Percent incidence of blister at six Disease Survey Plots, 1995 - 1996, by tree diameter class. Seedling/sapling = 0 - 4.9" dbh; pole = 5 - 10.9" dbh; small sawtimber = 11 - 20.9" dbh; large sawtimber = 21" and larger dbh.

Number of Sugar Pine by Tree Diameter Class

The Disease Survey plots were intentionally placed in young mixed conifer stands and therefore had a high percentage of stems in seedling and sapling size classes and fewer in the larger size classes. The original data did not specifically record size class for sugar pines present on the plots. However, sugar pine that did have dbh (1" or greater diameter at breast height) were recorded with an estimated dbh. These sugar pine were not tagged. Using that data, it was possible to summarize the number of sugar pine in each of four diameter classes at each plot over time. The data are presented in Table 4.

There was an increase in the number of sugar pine 11" dbh or greater (small sawtimber and large sawtimber) on all plots except Bumblebee Creek, where the number remained the same. The number of poles (5 - 10.9" dbh) increased on all plots except one (Middle Meadows 2).

Table 4. Number of sugar pine, by tree diameter class, at six Disease Survey plots.

Plot	Year	Number of Sugar Pine			
		seedling/sapling	pole	small sawtimber	large sawtimber
		(0-4.9" dbh)	(5-10.9"dbh)	(11-20.9"dbh)	(21" + dbh)
Spaulding Creek	1950	505	15	11	1
	1956	471	18	9	2
	1996	134	81	19	0
Mayflower Ranch	1950	73	0	0	0
	1955	56	4	0	0
	1996	16	5	1	0
Bumblebee Creek	1949	176	1	2	0
	1953	197	0	0	0
	1996	33	14	2	0
Howard Creek	1950	153	5	3	1
	1996	31	7	12	5
Spring Garden Ridge	1950	401	11	2	0
	1955	380	13	2	0
	1995	30	22	9	2
Middle Meadows 2	1950	95	13	5	0
	1996	28	5	4	9

There was a significant reduction in the number of sugar pine in the seedling/sapling size class on all of the six plots. For example, the number of sugar pine at the Spaulding Creek plot in the 0 - 4.9' dbh class decreased from 505 in 1950 to 134 in 1996, a reduction of about 73%. At Spring Garden Ridge, the reduction was over 90%. Although some of this reduction was probably due to blister rust, we cannot say how much. Based on knowledge of how "normal" stands grow, and on the relatively low levels of rust currently present, the loss due specifically to rust-caused mortality was probably low.

A typical stand begins with a relatively large number of small trees, usually thousands per acre, then the number decreases as the trees grow larger. This reduction in numbers is primarily the result of competition for light, moisture and nutrients, and the weaker, suppressed trees die. This obviously occurred in the Disease Survey plots.

Is the mortality of sugar pine over time in the seedling/sapling diameter class reasonable? Unfortunately, the available data for each plot is only for sugar pine, and not for the stand

as a whole. However, if an assumption is made that the six plots are representative of a typical stand, some inferences can be made. Some numbers are available for second growth mixed conifer stands in California (Dunning and Reineke, 1933). On a relatively good site, with a site index of 80 (as, on the average, the Disease Survey plots are) the number of trees/acre in a 30 year old stand is 1,120 and decreases to 277/acre in a 80 year old stand. This is a reduction of about 75%, and within the range of observations in the Disease Survey plots. Numbers for Douglas-fir, a species with intermediate tolerance to shade similar to sugar pine, are similar (Schumacher, 1930). A Douglas-fir stand on a good site at 30 years of age contains about 430 trees/acre in the 0 to 4" dbh class. This number is reduced to 30 in a 70 year old stand, a reduction of about 91%.

The above suggests that the mortality of sugar pine seedlings and saplings over a 45 year time period on the Disease Survey plots is reasonable, even without the presence of blister rust as a mortality factor.

Number of *Ribes* Bushes and Rust Incidence

Data on number of *Ribes* bushes and incidence of rust on the host is presented for each of the six Disease Survey plots in the Appendix. The data are summarized in Table 4.

Table 4. Incidence of *Ribes* and rust at six Disease Survey plots.

Plot	Year	Number of *Ribes* Bushes	
		Total	Infected
Spaulding Creek	1950	1	1
	1956	0	0
	1996	2	0
Mayflower Ranch	1950	9	1
	1952	3	3
	1955	3	3
	1996	0	0
Bumblebee Creek	1949	0	0
	1953	2	0
	1996	0	0
Howard Creek	1950	352	0
	1952	352	0
	1953	351	0
	1957	346	2
	1996	59	9
Spring Garden Ridge	1950	9	0
	1955	60	0
	1995	54	38
Middle Meadows 2	1950	37	0
	1996	106	61

[illegible]

[illegible] 1973 [illegible] Pettersen [illegible] (1973) [illegible]

[illegible] suggests [illegible]

[illegible] Disease Survey [illegible]

[illegible]

[illegible] number of [illegible] on the [illegible] Disease Survey plots in the Appendix [illegible]

Table 1. Incidence of [illegible]

[illegible]

The highest number of infected *Ribes* bushes (61) occurred at Middle Meadows 2, where rust infection on sugar pine was 13%. However, there is no obvious correlation between percent sugar pine infected and total number or infected number of *Ribes* bushes on the plots. For example, at Bumblebee Creek, 18.4% of the sugar pine were infected, but no *Ribes* were present. At Howard Creek, 14.5% of the sugar pine were infected and no *Ribes* were present.

Conclusions

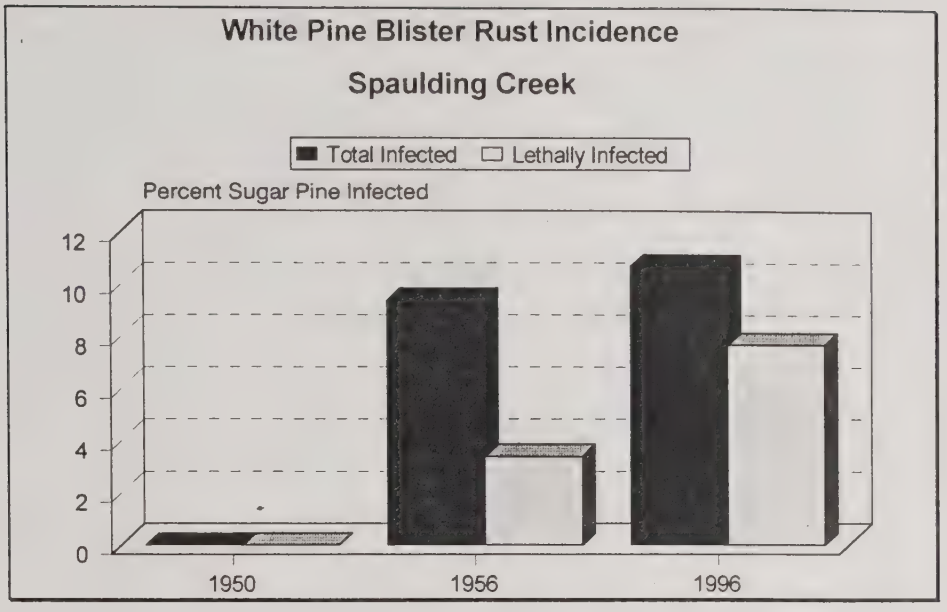
Incidence of blister rust at six permanent, one acre plots, at two or three points in time, is available. It is difficult to draw conclusions about the incidence of rust and it's effect on sugar pine with only 2 or 3 time measurements and no observations or data from intermediate time periods. These plots should be re-measured at 5 to 10 year intervals to give a historic perspective of the disease incidence at specific locations, over time. Individuals responsible for establishing original plots did an extraordinary job of record keeping, making it relatively easy for the plots to be re-located some 45 years later. Hopefully the records of the 1995-1996 re-monumenting and re-measuring will be as useful in the future.

The re-measurements of rust incidence indicated that healthy, reproducing, sugar pine remain, despite the presence of the introduced pathogen for some 45 years, in areas where the rust may now be considered endemic. Except for the low levels of rust recorded at Mayflower Ranch (the levels may be low because only a few sugar pine were recorded on the plot), there was not much variability in percent infection by plot location.

Literature Cited

Dunning, D.; Reineke, L.H. 1933. Preliminary yield tables for second-growth stands in the California pine region. USDA Technical Bulletin No. 354, Washington, D.C. 24 pp.

Schumacher, F.X. 1930. Yield, stand and volume tables for Douglas-fir in California. University of California, College of Agriculture, Agricultural Experiment Station Bulletin 491. 41 pp.



1950

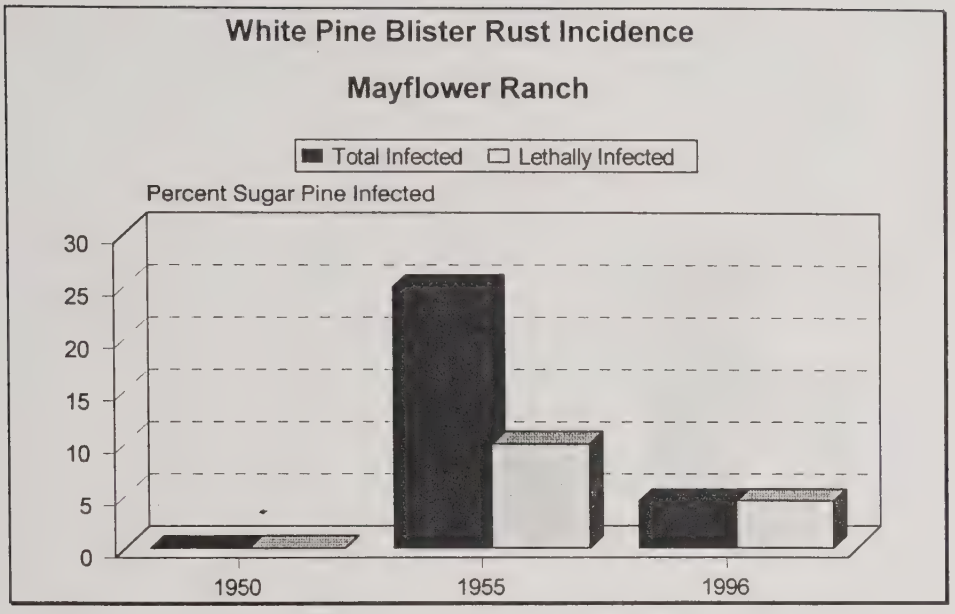
The plot and surrounding area had not been logged.
Rust light on plot, but heavy nearby on dense sugar pine reproduction.
532 trees were examined on the plots; 21 were infected (7 with trunk cankers); 20 infected trees were removed at time of plot establishment.
Rust in adjacent stands first recorded in 1937.
Infections were aged at 1944, 1947.
Only one *Ribes* bush on the plot; infected with rust.

1956

502 remaining sugar pine were examined; 47 were infected (9.4%), 17 with bole cankers (3.4 % lethal). Some trees with bole cankers were removed, others were not.
Infections were aged at 1941 (3), 1944 (1), 1947 (19), 1949 (30), 1948 (10), 1950 (1), and 1951 (1).
No *Ribes* were recorded on the plot.

1996

234 remaining sugar pine were examined; 25 were infected (10.7%), 18 with bole cankers (7.7% lethal).
38 sugar pine were dead from recent mountain pine beetle attacks.
Two *Ribes* bushes were recorded; both were infected.



1950

Only light previous logging; no mature sugar pine, and only a few mature of other species, on the plot.
Widespread rust infection; majority of cankers were pre- 1944 origin; most were 1941.
Ribes eradication occurred in 1949, but found 9 bushes in 1950; 1 of the 9 was infected.
73 sugar pine were examined; 15 with trunk cankers were removed.
Nine *Ribes* bushes were recorded; one was infected.

1952

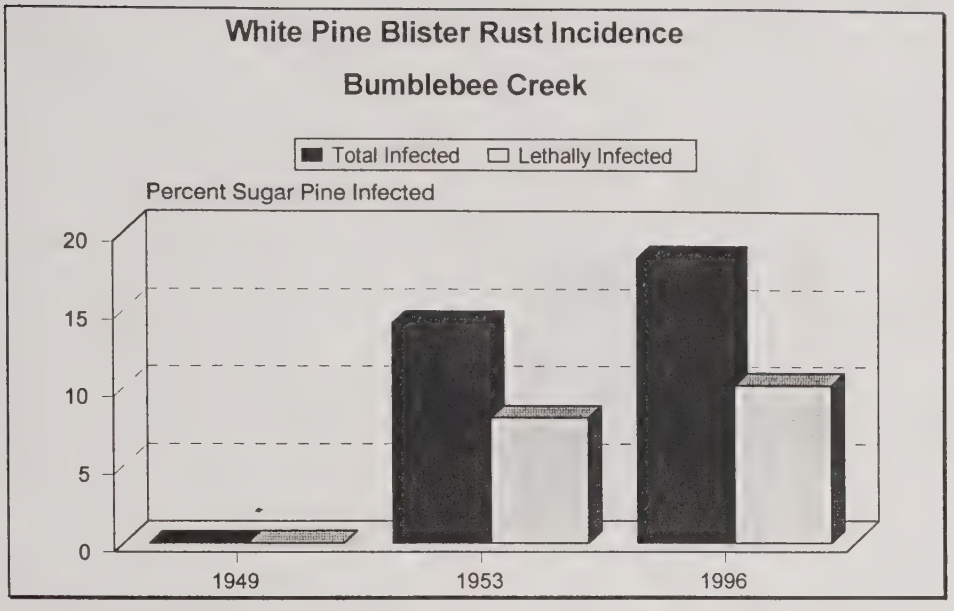
Re-examined *Ribes* only. Found 3 bushes, all with heavy rust infection.

1955

Re-examined pine and *Ribes*.
60 trees were examined; 15 were infected (25%), 6 with bole cankers (10% lethal).
Three *Ribes* bushes were recorded; all three were infected.

1996

22 trees examined, 1 (4.5%) with rust (bole canker).
No *Ribes* were recorded on the plot.



1949

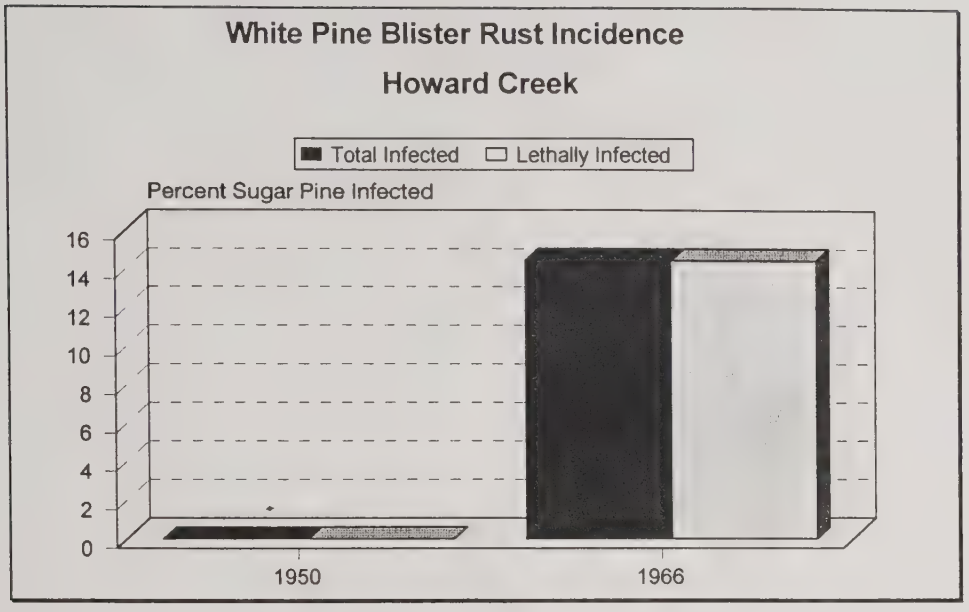
Area cut over (timber removed) 15 to 30 years previously.
Rust first appeared in the area in 1937, with a wave year in 1941.
Ribes eradication work occurred in 1942, 1946, and 1949.
179 trees were examined; 26 were infected, 20 with bole cankers; all infected trees were removed when the plot was established.
No *Ribes* were recorded on the plot.

1953

197 trees (18 more than in 1949) were examined; 28 (14.2%) had cankers, 16 (8.1%) with bole cankers.
Only two *Ribes* bushes were recorded; none were infected.

1996

49 sugar pine were examined; 9 (18.4%) had rust, and 5 (10.2%) of these had bole cankers.
No *Ribes* were recorded on the plot.



1950

Heavily logged in the past; only one mature sugar pine on the plot.
Rust infection scarce in the surrounding area.
162 trees were recorded (10 as dbh, the remainder were tagged); 2 others were infected (1944 infection, bole cankers), and were cut.
No infection on 352 *Ribes* bushes recorded.

1952

Ribes re-examine only.
352 *Ribes* bushes were recorded; no rust was present.

1953

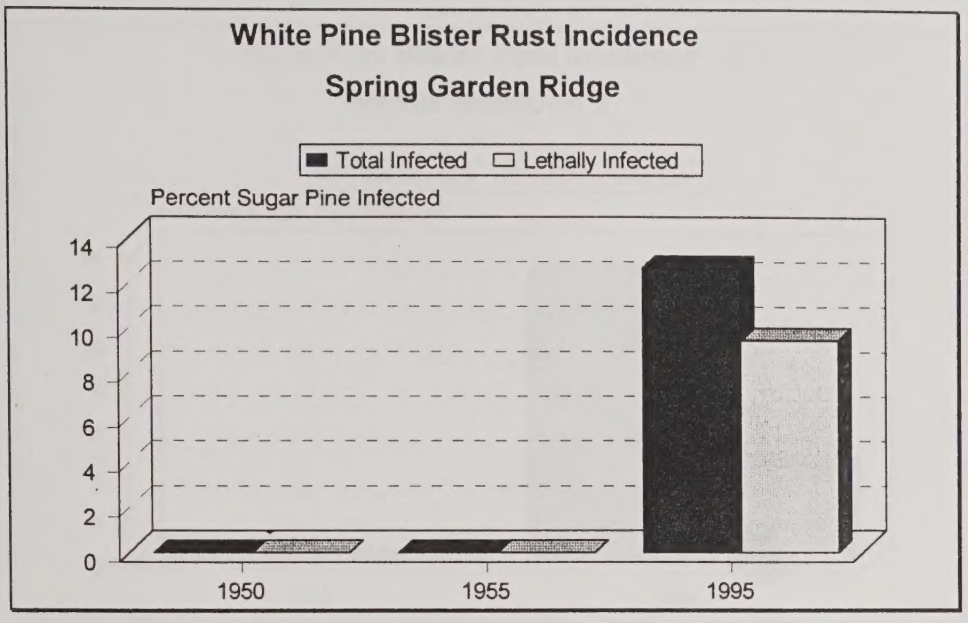
Ribes re-exam only; no infection.

1957

Ribes re-exam only; 2 bushes were infected.
(Although rust had been present on sugar pine since 1944, no rust was recorded on *Ribes* until 13 years later)

1996

55 sugar pine were recorded; 8 (14.5%) were infected with bole cankers.
59 *Ribes* bushes were recorded; 9 were infected.



1950

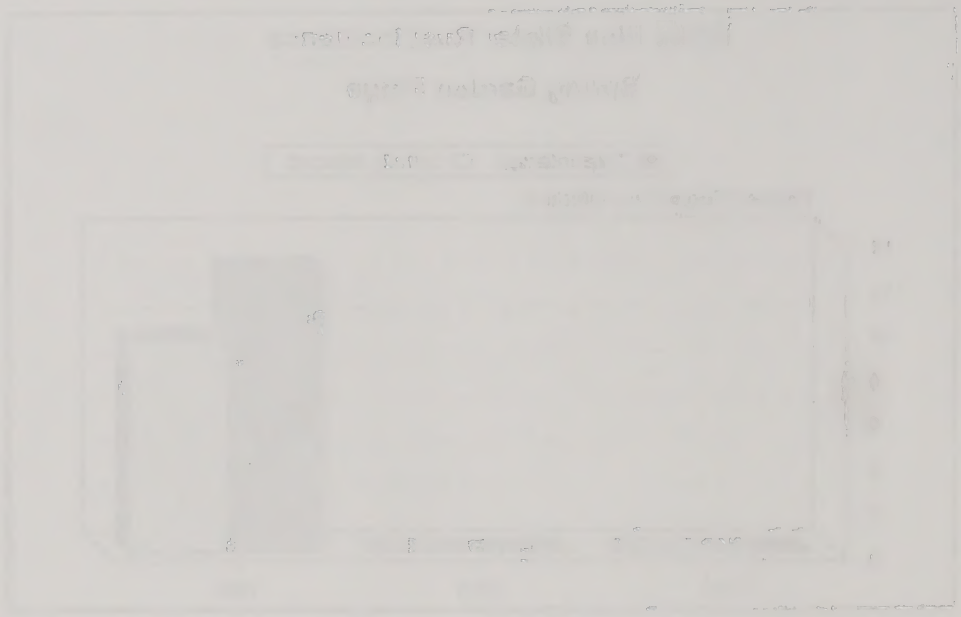
Area heavily logged in recent past, with only a few mature incense-cedar and white fir on the plot.
414 sugar pine were recorded (19 as dbh, 395 tagged); an additional 2 had bole cankers (1944 origin) and were removed.
9 *Ribes* bushes, all rust-free, occurred on the plot.

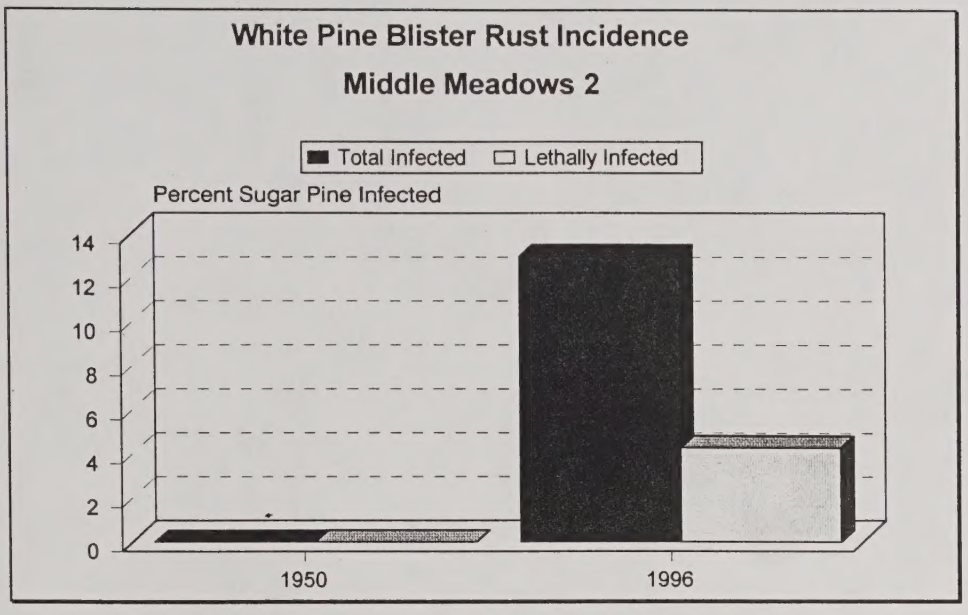
1955

395 sugar pine were recorded; none (0%) had rust.
76 of the 395 trees were recorded as damaged, killed or missing from recent logging damage, and 5 had porcupine damage.
No rust was recorded on 60 *Ribes* bushes.

1995

Eight trees with original tags, and a corner stake, were located; these tagged trees had grown an average of 10" in diameter in 45 years.
63 sugar pine were recorded; 8 (12.7%) had rust, and 6 of the 8 (9.5%) had bole cankers.
Rust was common on numerous *Ribes* bushes; 54 bushes were recorded, 38 with rust.





1950

Plot established in a mature stand of ponderosa pine, white fir, incense-cedar, and sugar pine.
108 sugar pine (82 trees were tagged) and 37 *Ribes* bushes were recorded; no rust was present.

NO re-examinations were done.

1996

46 sugar pine were recorded; 6 (13%) had rust, and 2 (4.3%) had bole cankers.
Rust was very common, and heavy, on *Ribes*; 61 of 106 bushes recorded were infected.